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Selected Findings from FTA Traffic Assignment & Feedback Research

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Project Motivation

- Congressional interest in highway benefits of major transit improvements

- Congested travel times underpin nearly all travel demand modeling components and forecasts for other purposes

- Convergence problems have been identified as a source of error in models

- FTA is interested in the reliability of MPO models for producing estimates of congested travel times for New Starts funding evaluation

Traffic Assignment and Feedback Research Project Overview

- Inventory/Assessment of the regional models of the 30 Largest Metropolitan Planning Organizations (MPOs)
- In-depth review of 5 of the better MPO Models
- Examination of Traffic Assignment Methods
- Examination of Feedback Methods
- Project Impact Analysis
- Comparison of Modeled & Measured Travel times
- Cross-cutting Conclusions

Assessment of Current Practices (2011)

- Nearly universal coverage of the 30 largest MPOs
- Widespread deficiencies found in traffic assignment methods
- Use of problematic assignment techniques and closure metrics – only 50% used a good metric
- Of those, low convergence targets for the relative gap- many at .01 or larger, few at .001, 2 at .0001
- Feedback insufficiently computed when attempted-often only one time period, ad hoc methods and metrics, often stopping at 5% flow diff.

Research Questions

- How much convergence error is there in deployed regional models?

- How much convergence is enough for project evaluation?

- How hard is it to achieve with current algorithms and commercial software?

- How significant is feedback convergence?

- How achievable is feedback convergence?

- How realistic are model-generated congested travel times?

Analysis Approach for Empirical Work

- Work only with real, deployed models using those from the Atlanta, Phoenix, Dallas-Ft. Worth, San Diego, and Seattle MPOs

- Examine and review methods and their implementation

- Perform empirical tests of model variants and project impacts using highly convergent assignment methods

- Examine how project impact assessments are influenced by chosen methods and convergence levels

- Compare congested travel times with those from commercial sources

Convergence Behavior of TA Models
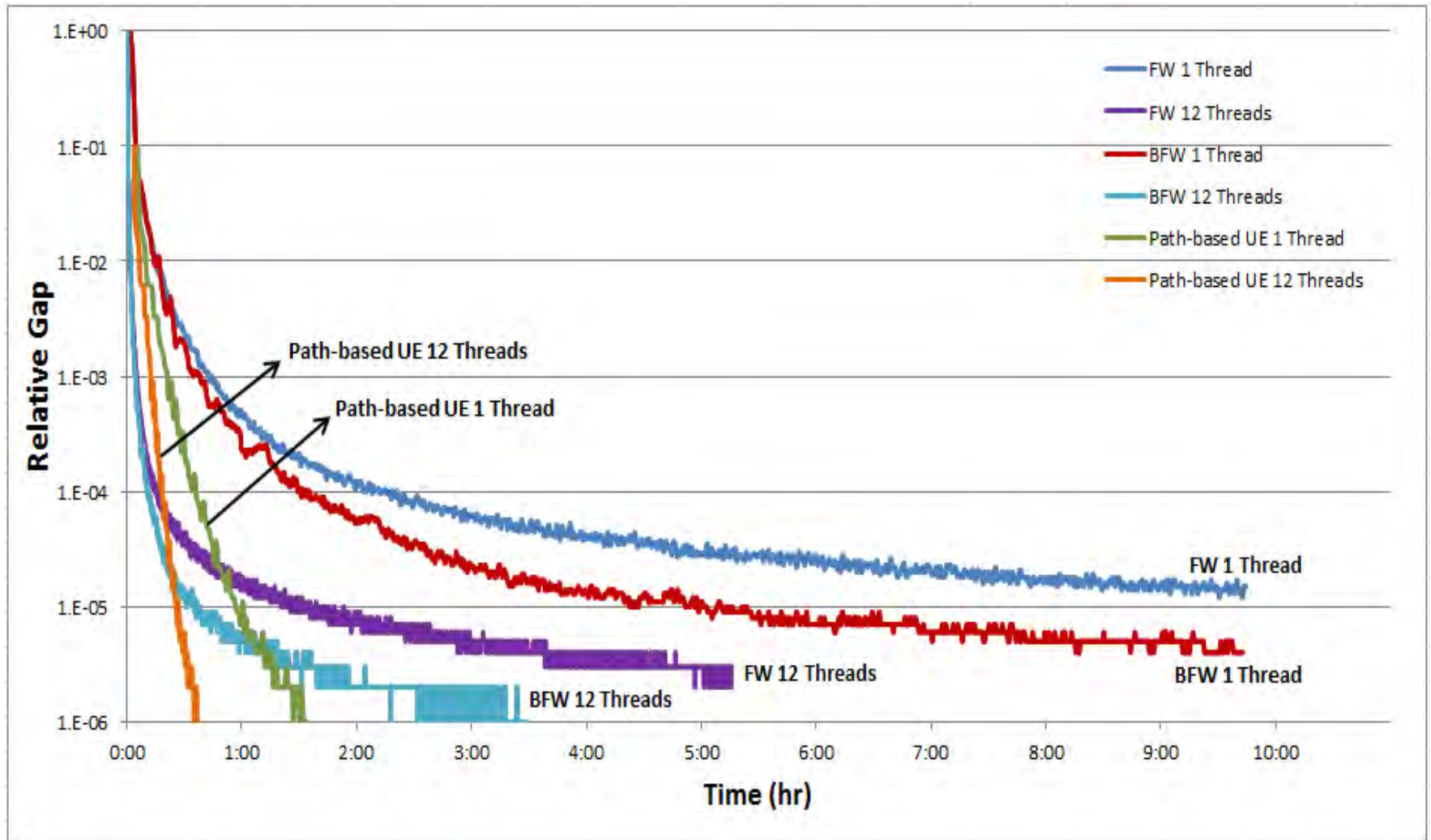
Example of Assignment Convergence Error: Impact of Blue Line Service Improvements at 1% Relative Gap
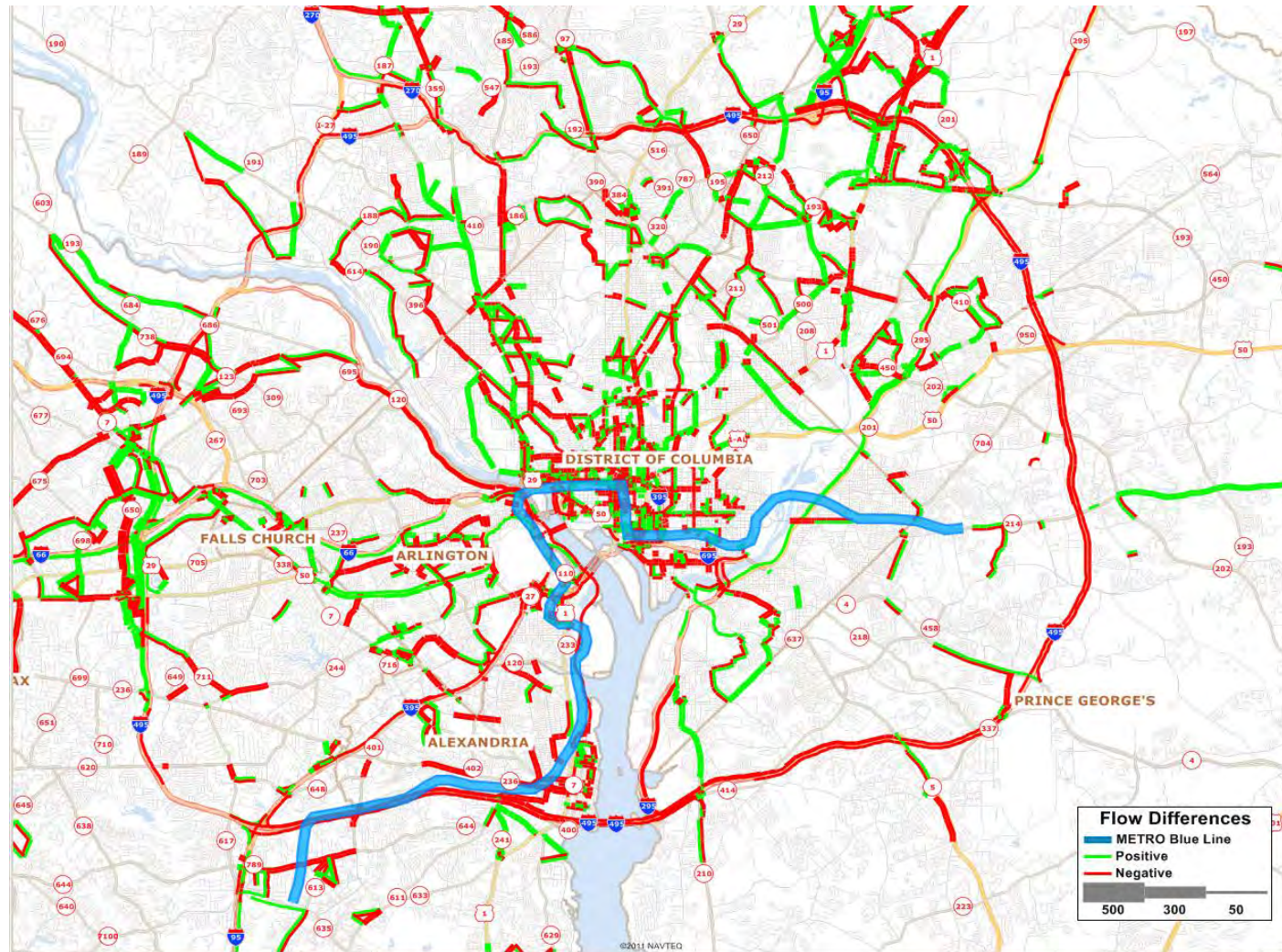
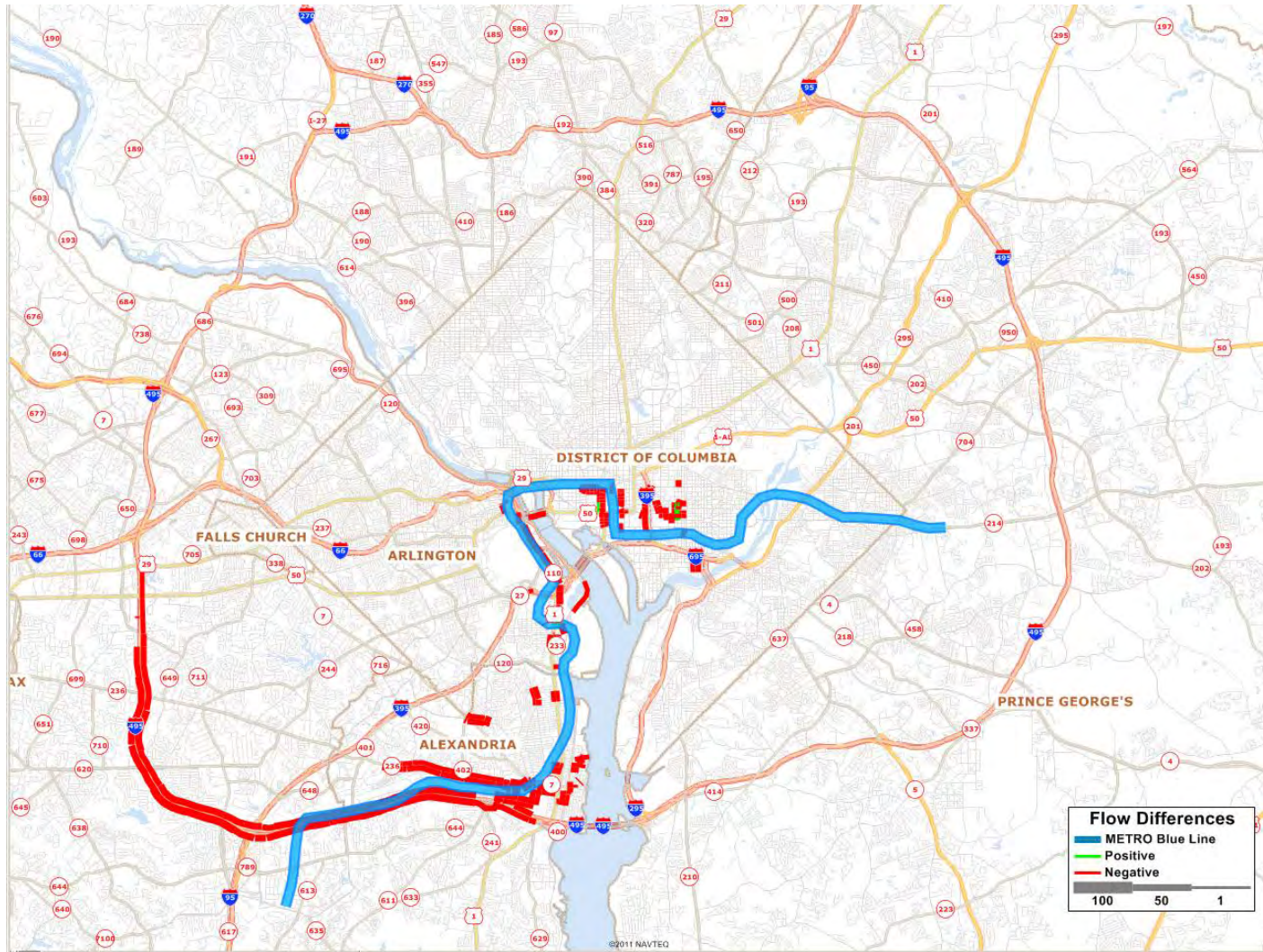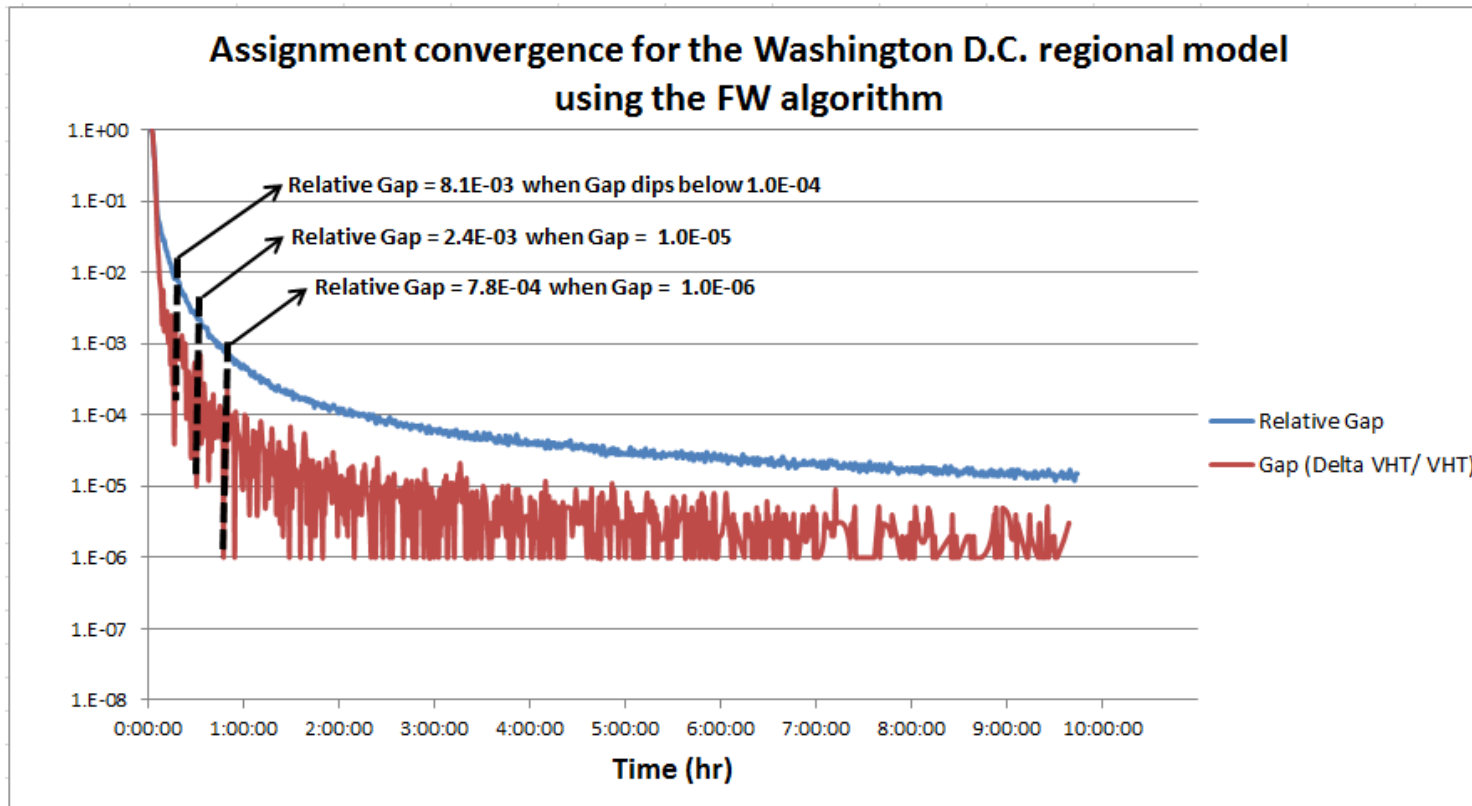# Road Impacts of Blue Line Service Improvements at 1E-6 Relative Gap

Illustration of misleading convergence from the GAP measure

Assignment convergence for the Washington D.C. regional model using the FW algorithm

Relative Gap = 8.1E-03 when Gap dips below 1.0E-04

Relative Gap = 2.4E-03 when Gap = 1.0E-05

Relative Gap = 7.8E-04 when Gap = 1.0E-06

Relative Gap

Gap (Delta VHT/ VHT)

Time (hr)

Feedback Research Questions

- Basic Methodological Framework
- Convergence Metrics
- Convexity/Uniqueness Issues
- Computational Approaches
- Achievable Convergence Levels
- Computational Burden

How much does good practice or bad practice matter?

- Central question for our empirical work
- Relevant to many modeling choices
- Test whether methods good in theory are reliable in practice
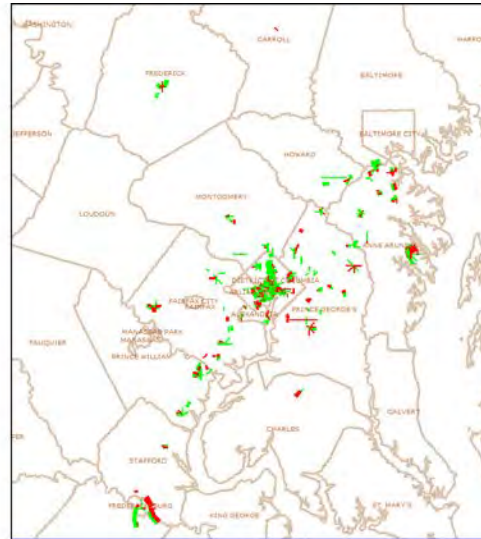- We attempted to find and quantify the answers through exhaustive empirical testing of model variants

How much error is there in the link flows in an unconverged assignment?

- Can be quantified
- Using the convergence abilities of improved methods, we can compare less converged solutions with highly converged ones
- TransCAD's path-based method used to reach the necessary 1.E-07 relative gap
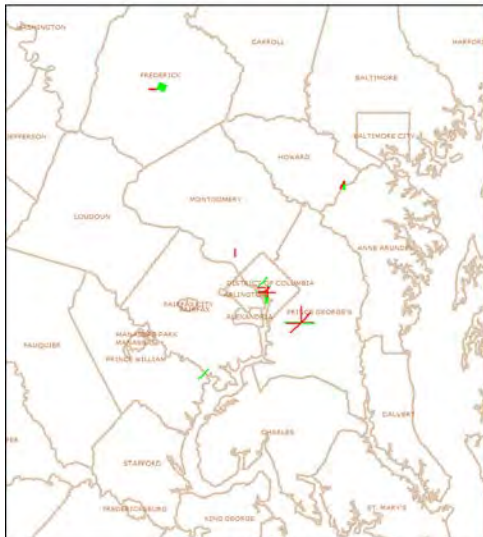
Flow difference maps comparing assignments at different relative gaps
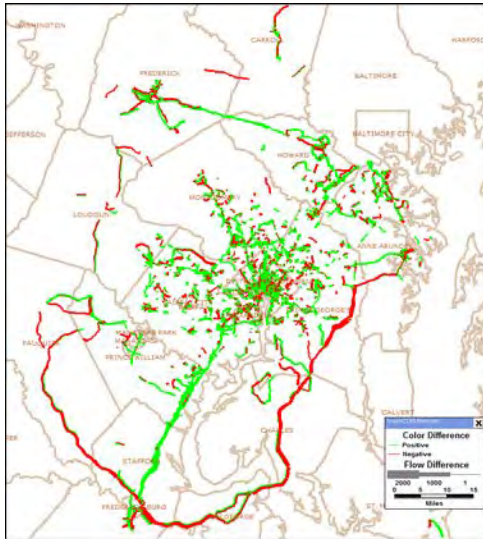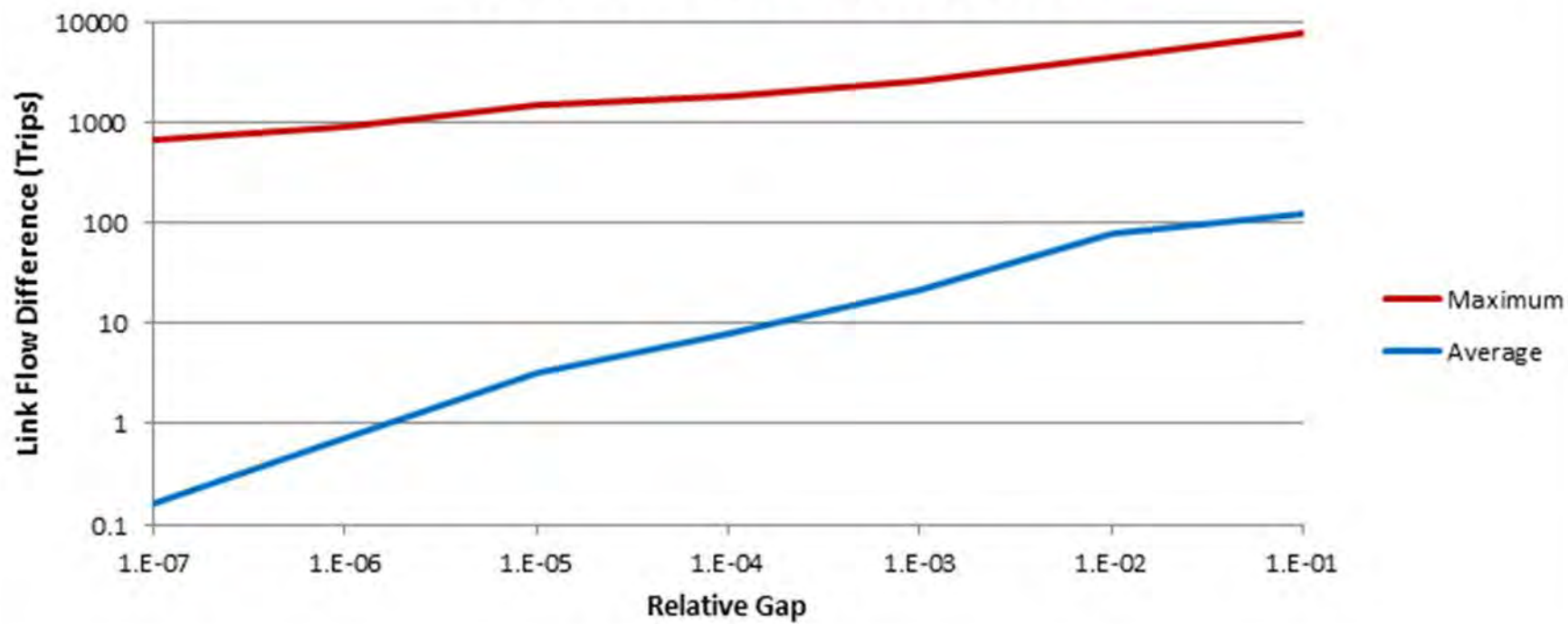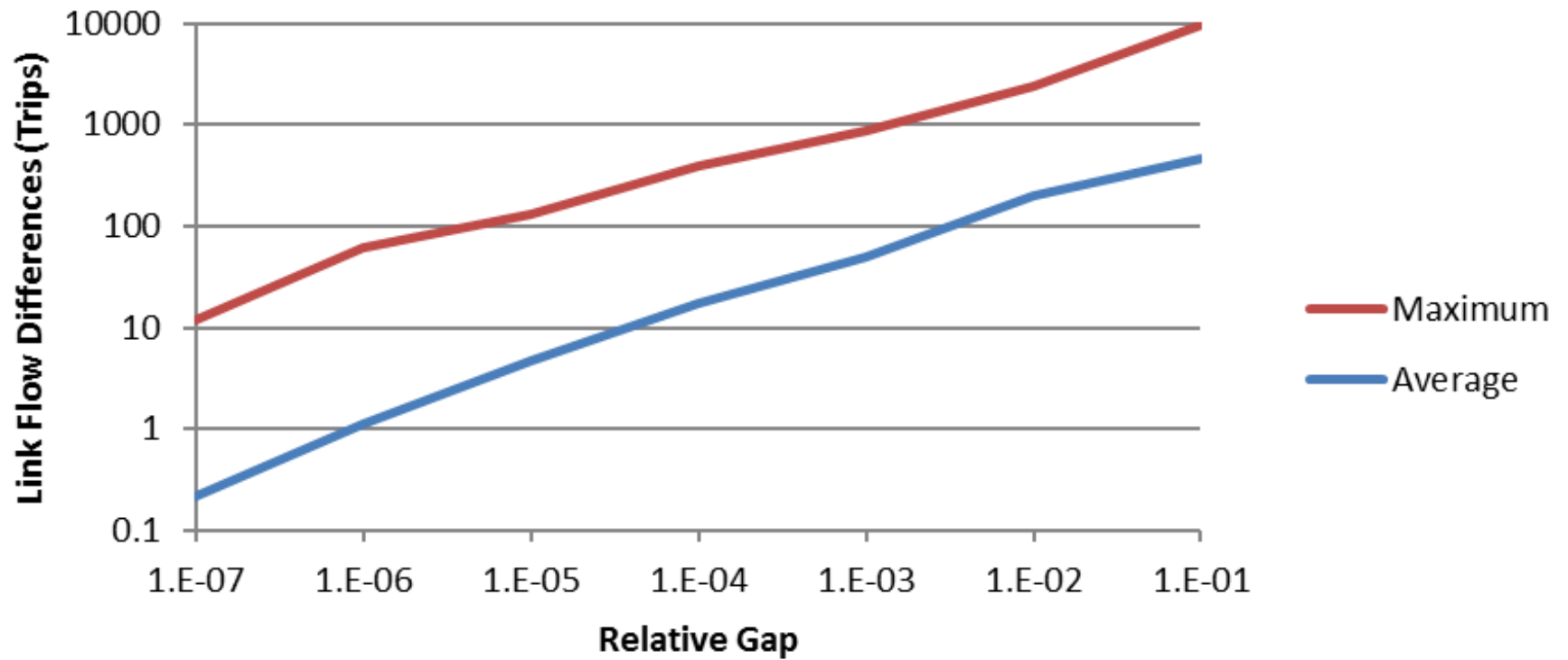

Gap 0.01

Gap 0.001

Gap 0.0001

Gap 0.00001

Flow Convergence Errors: MAG

Y-axis: Link Flow Differences (Trips) — 0.1, 1, 10, 100, 1000, 10000

X-axis: Relative Gap — 1.E-07, 1.E-06, 1.E-05, 1.E-04, 1.E-03, 1.E-02, 1.E-01

Legend: Maximum, Average

Characteristics of the MPO Traffic Assignment Models

- All larger than examples in the research literature-with more zones, more links, more user classes, more congestion

- More varied volume-delay functions than BPR, some with intersection delay

- Nevertheless, all models can be converged to a relative gap of .0001 or lower with a suitable algorithm in a modest amount of time aided by better algorithms and multi-threading

Assignments to 1E-4 Relative Gap with the Bi-conjugate FW Algorithm on a 12 core computer

MPO	ARC	MAG	NCTCOG	PSRC	SANDAG ABM	SANDAG trip-based
METHOD	BFW	BFW	BFW	BFW	BFW	BFW
TIME PERIOD	AM	AM	AM	AM	AM	AM
CONVERGENCE	1.E-4	1.E-4	1.E-4	1.E-4	1.E-4	1.E-4
NUMBER OF ITERATIONS	80	51	153	66	45	39
COMPUTATIONAL TIME	32 min	7 min 19 s	31 min	40 min	35 min	26 min
TOTAL VMT	40,264,910	29,356,528	35,209,830	13,122,656	16,934,816	15,727,035
TOTAL VHT	1,244,615	889,645	1,089,180	447,006	490,625	443,486

Traffic Assignment Validation

- Current validation against counts appears quite insufficient

- Counts must be by time period and direction to be useful for validation

- Minimum sample sizes are warranted for statistical significance

- Geographic bias often present

- Validation against both counts and speeds would be useful

- Validation of multi-class assignment is usually not performed, but should be
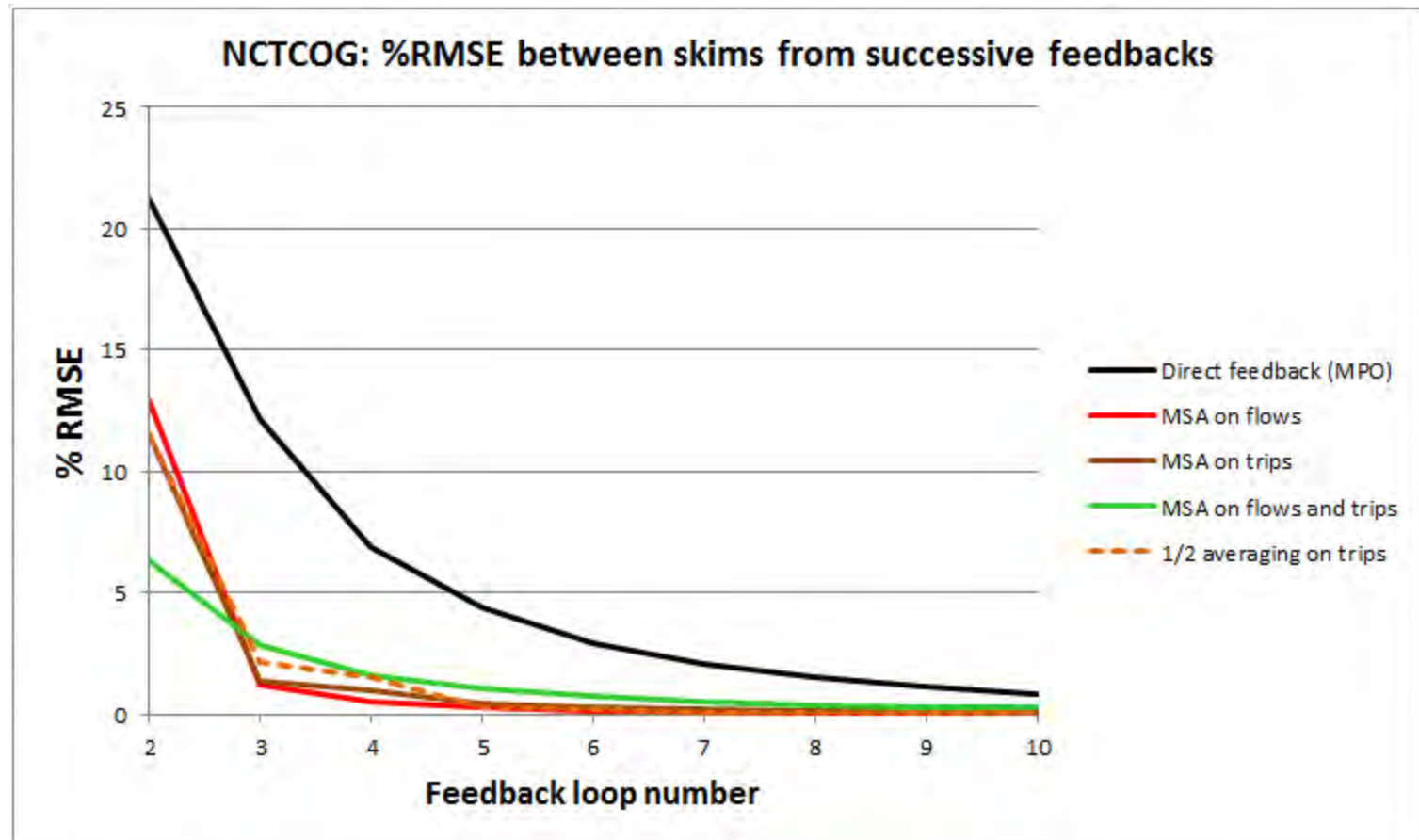
Comparison of Link Flows v. Counts
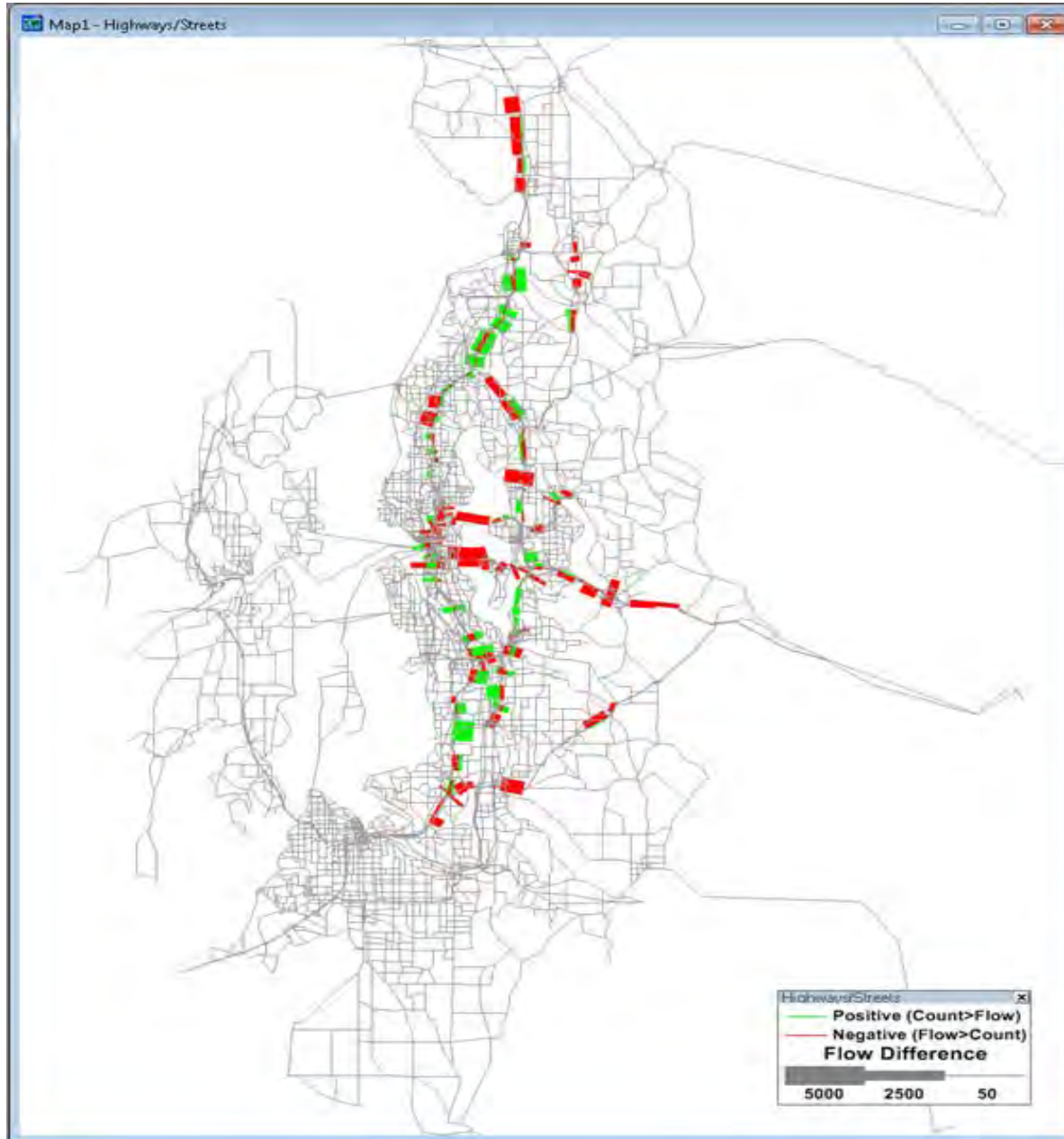
Traffic Assignment Findings

- Tighter convergence is useful and achievable with current software packages and published methods

- Deployed models have substantial convergence error and spurious project impacts

- The degree of convergence that is useful may be problem dependent and can be assessed through straightforward comparisons.

- Basic errors in model formulations are fairly widespread

Computing Model Feedback

- A necessary condition for achieving internal consistency in a multi-step travel model

- Limited prior research, some of which is flawed

- Differences of opinion about suitable closure metrics and solution approaches

- A fixed point problem of O-D travel times

- Various averaging methods can work but MSA on link flows or link flows and O-D trips appears reliable

- Unfortunately, to some, a practice of uncertain need

Comparison of Feedback Approaches

NCTCOG: %RMSE between skims from successive feedbacks

- Direct feedback (MPO)
- MSA on flows
- MSA on trips
- MSA on flows and trips
- 1/2 averaging on trips

VMT & VHT by Feedback Loop

Feedback loop (i)	VMT	Δ(VMT(i)-VMT(i-1))	VHT	Δ(VHT(i)-VHT(i-1))
3	29,222,733	1,036,666	880,107	54,326
4	29,444,422	221,689	892,475	12,368
5	29,538,199	93,777	897,617	5,142
6	29,592,119	53,920	900,650	3,033
7	29,632,825	40,706	902,827	2,177
8	29,658,799	25,974	904,217	1,390

Flows from MSA averaging and ½ averaging after 5 iterations can be quite different
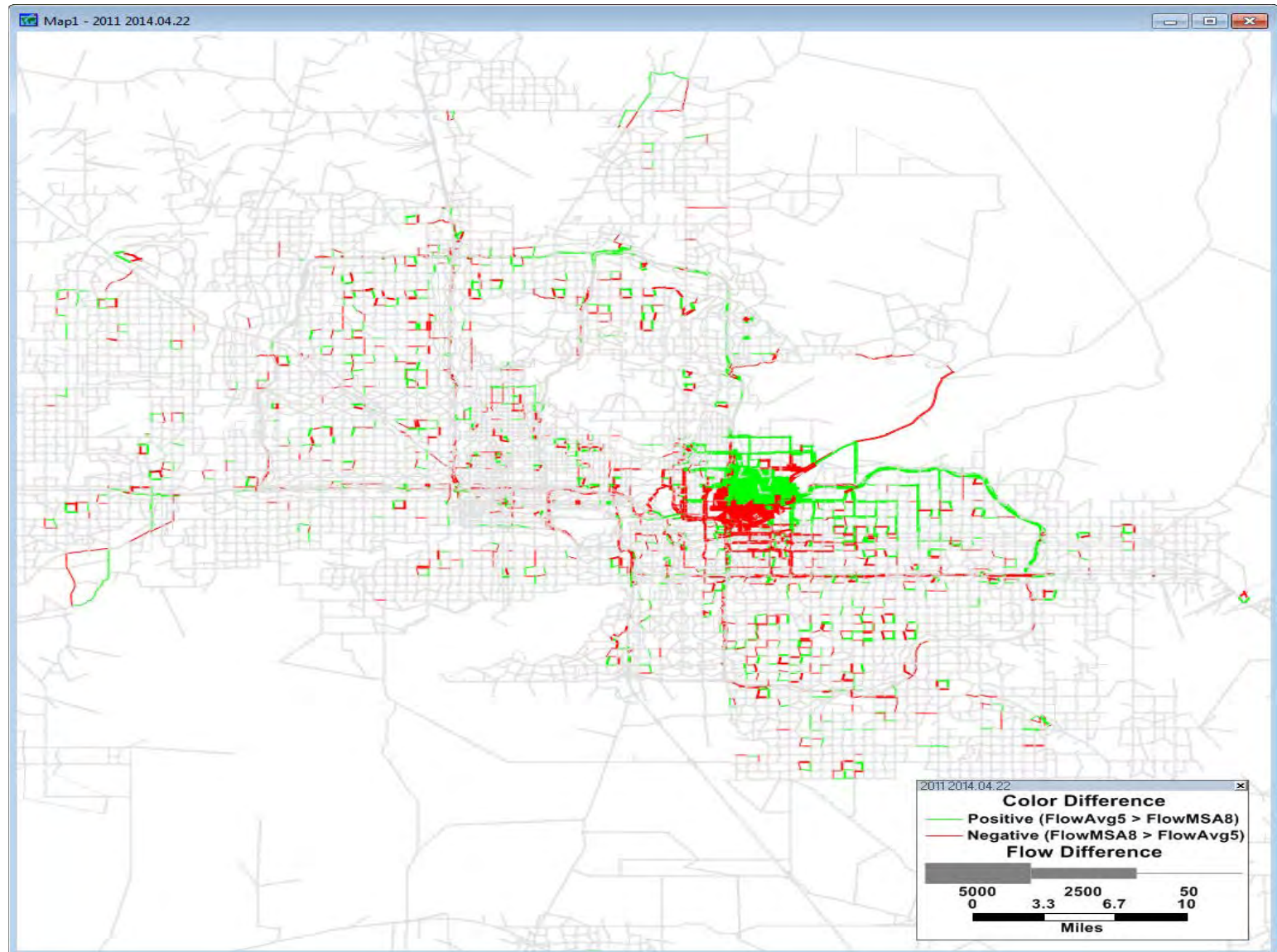
Feedback Findings

- Feedback computation changes the model flows significantly
- Different computational approaches lead to different link flows-methods leave their signature
- Very tight convergence is required
- Even so, small changes per loop can add up to significant differences
- Some activity-based models may have additional convergence issues

Feedback Good Practices

- Start with refined estimates of congested travel times for the first model loop

- Have an explicit formal, global definition of feedback convergence

- Use a valid feedback methodology

- Use tightly converged traffic assignments

- Achieve feedback convergence for each time period

Project Impact Analysis

- At least one highway project and one transit project for each region

- More extensive tests for MAG, NCTCOG, & SANDAG performed by Caliper

- Limited tests for ARC and PSRC

- Varied analysis protocols with and without feedback

# Example of a San Diego Region Road Project—New Section of SR 52
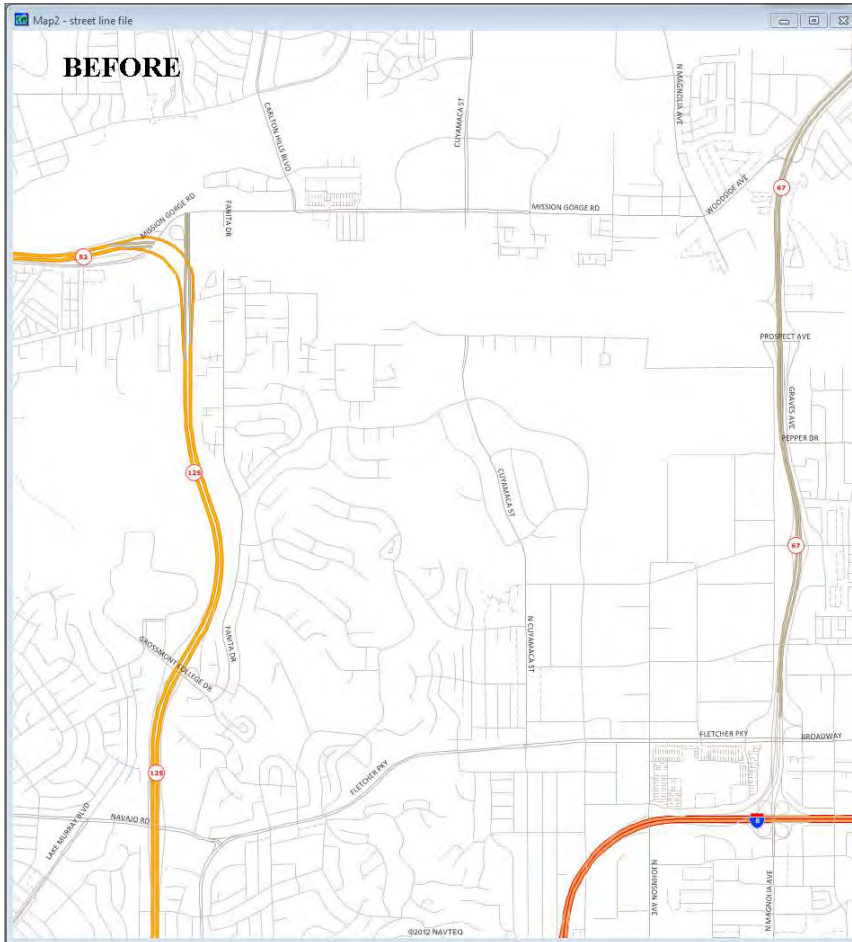
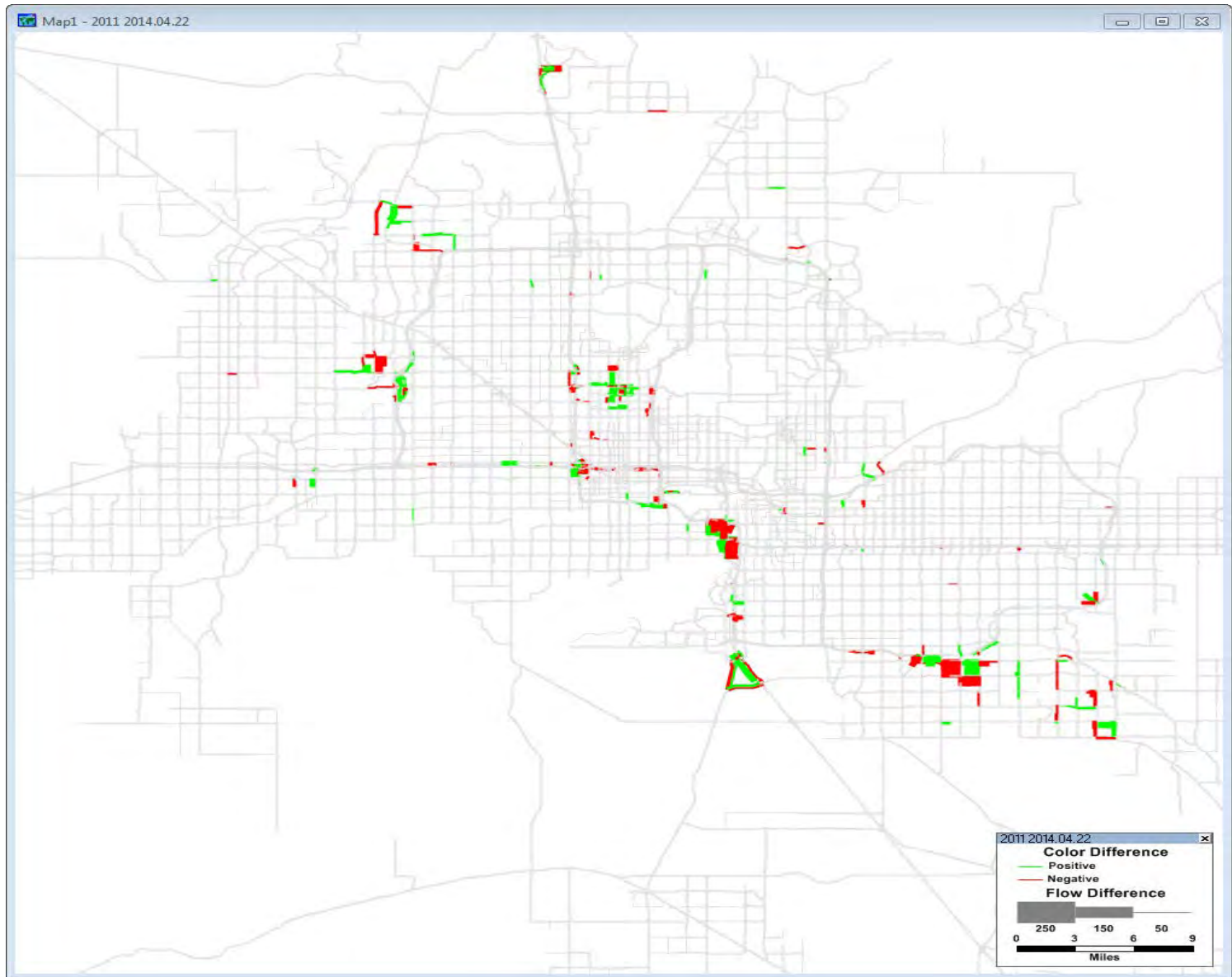| Highway assign Rel. Gap	Type of model run	Δ AM VMT (Project-base)	Δ AM VHT (Project-base)	Δ AM Highway trips	Δ AM Transit trips
5e-4	Highway AM assignment only	-33,360	-14,035	0	N/A (no transit assign)
1.E-5	Highway AM assignment only	-56,950	-3,172	0	N/A (no transit assign)
1.E-6	Highway AM assignment only	-56,850	-3,179	0	N/A (no transit assign)
5e-4	Single loop run with 100% ABM sample	-18,324	-1,262	+700	+1167
1.E-6	Single loop run with 100% ABM sample	-28,519	-1,644	+275	+30
5e-4	Full model with feedback	-17,582	-1,214	+658	+1161
1.E-5	Full model with feedback	-33,774	-1,952	+88	+1004
1.E-6	Full model with feedback	-26,197	-1,565	+390	+43

Table 7-10: SANDAG Highway Project Impact Summary
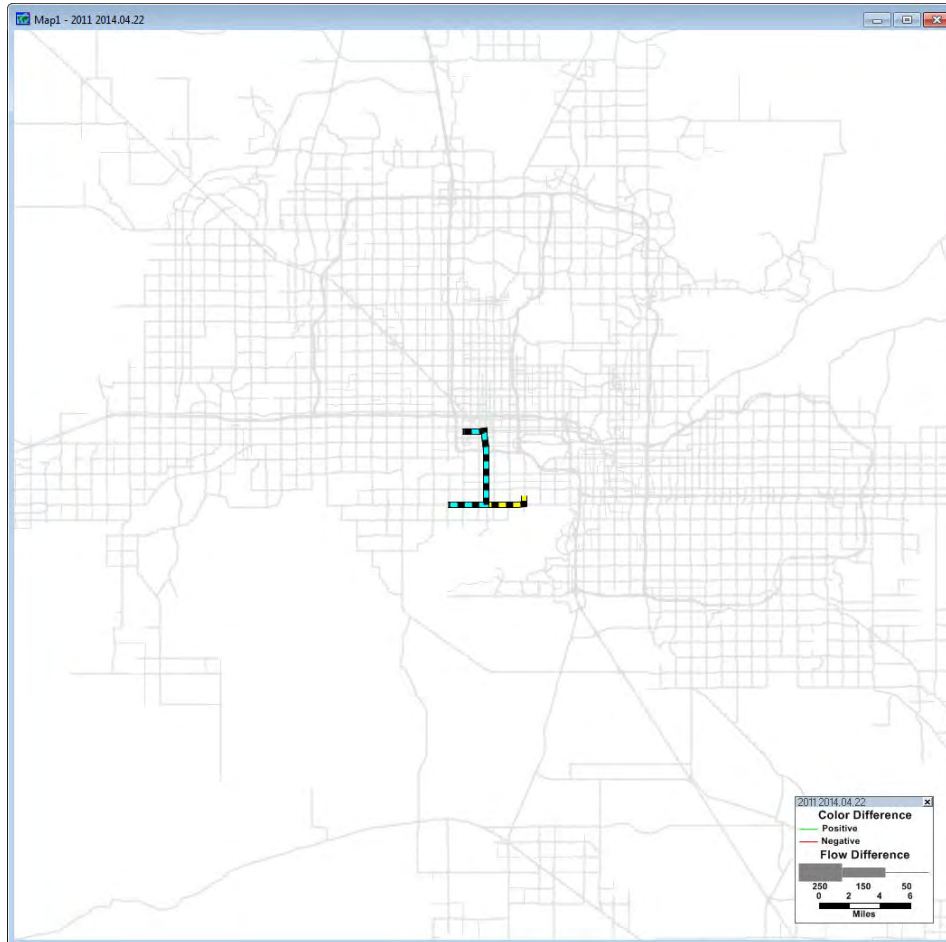
Two new transit routes in Phoenix
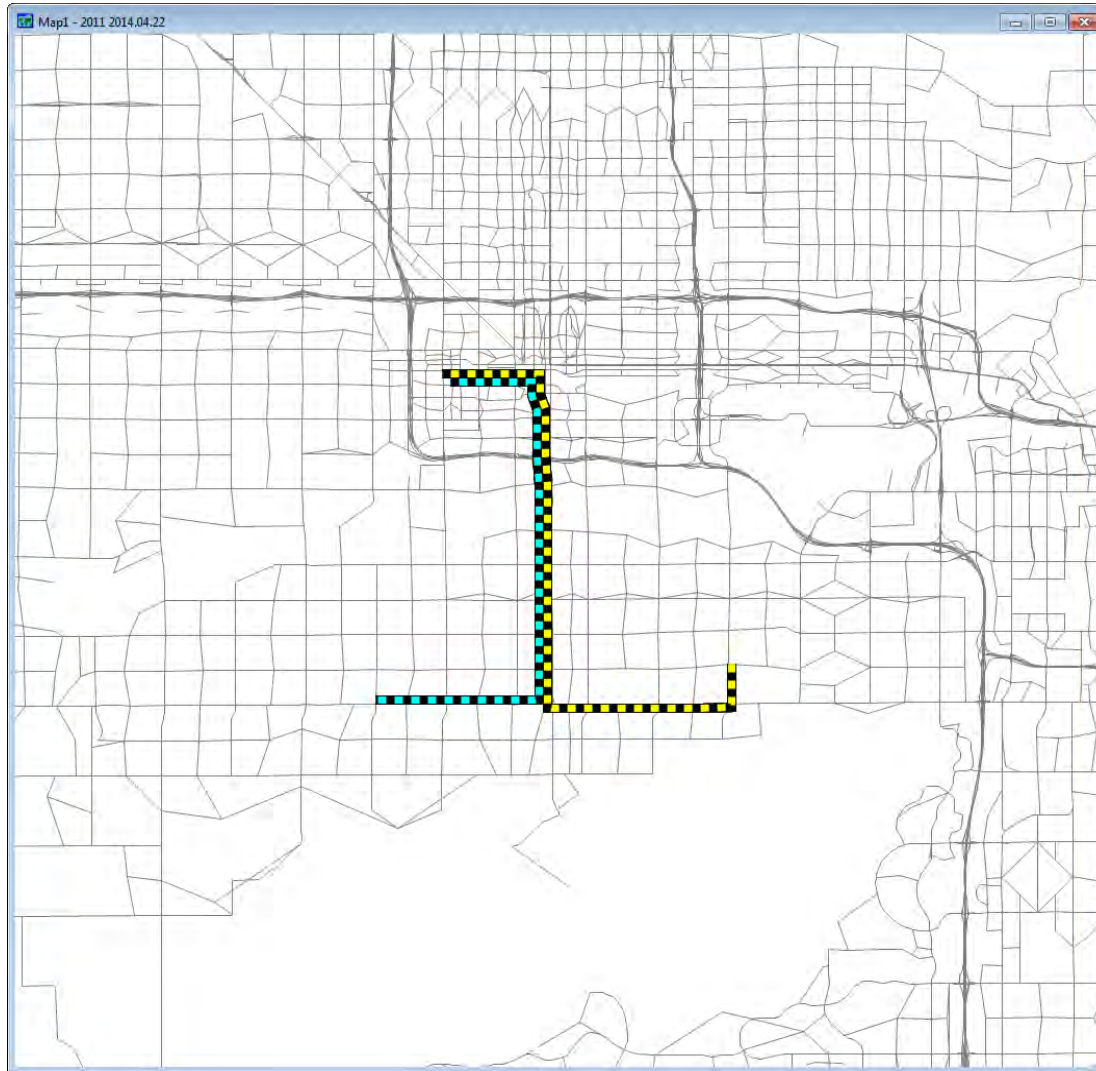
Transit Flow Changes
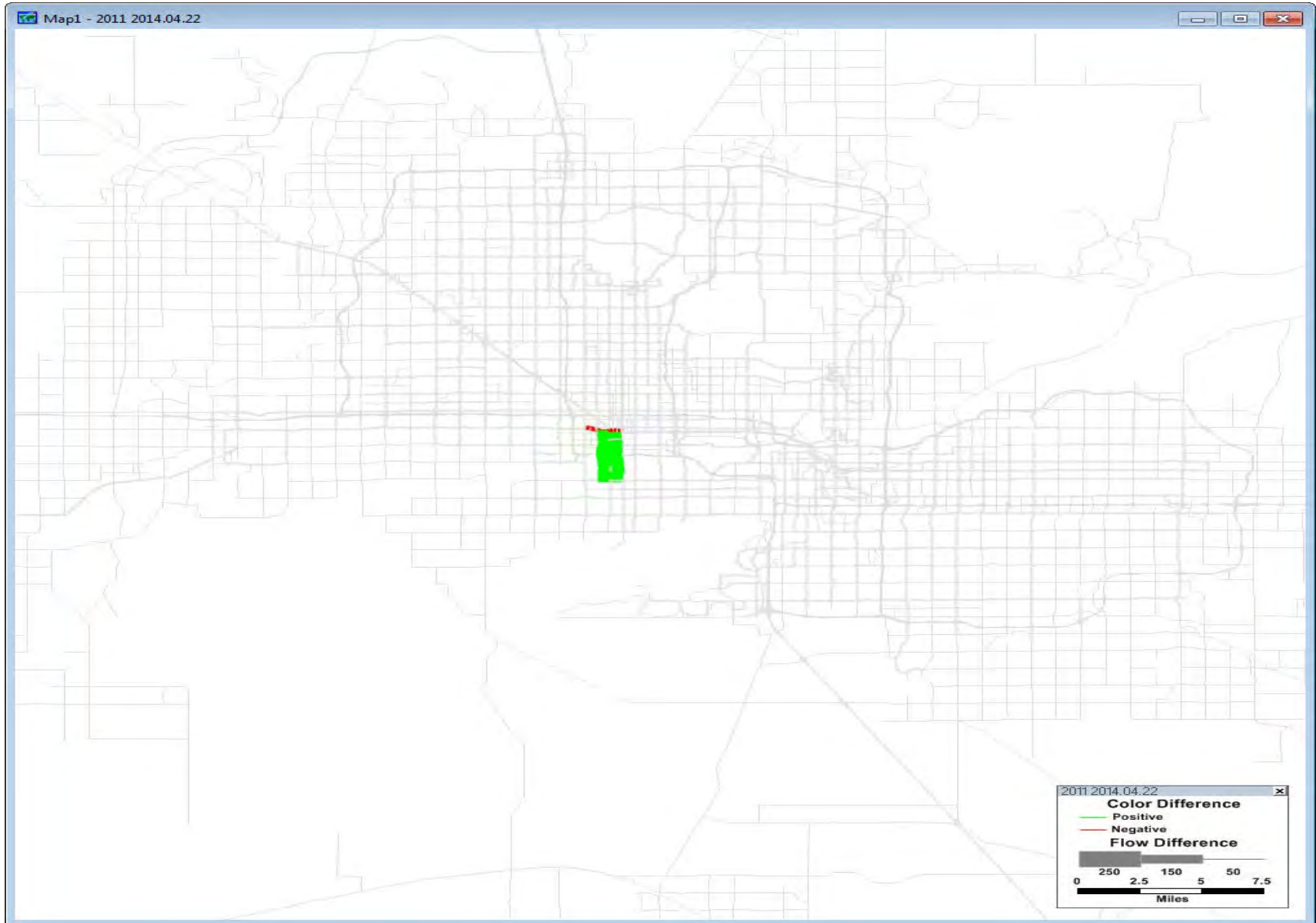
Highway Flow Changes at 1e-4
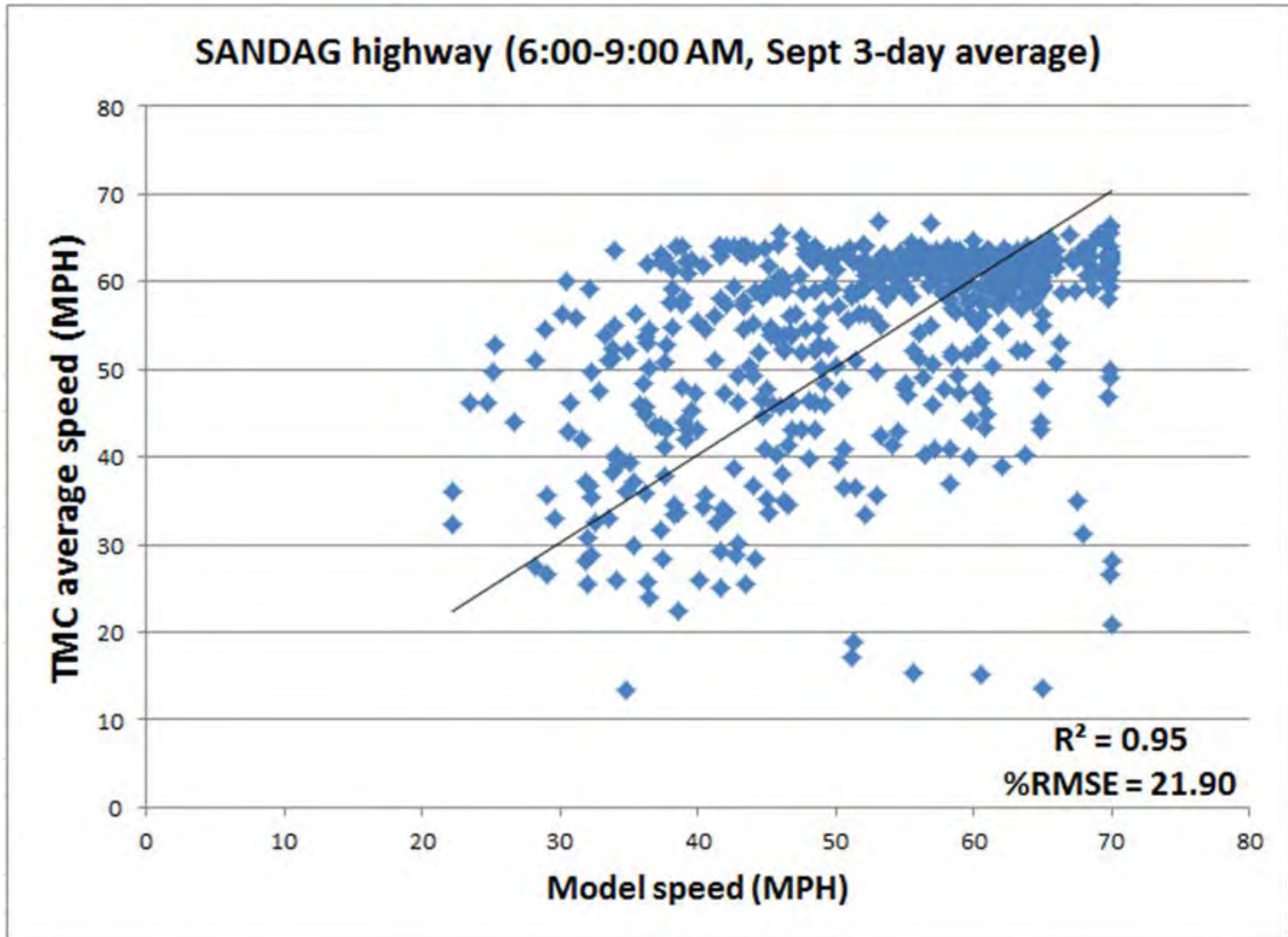
Highway Flow Differences at 1e-6

MAG Transit Project Run Summary

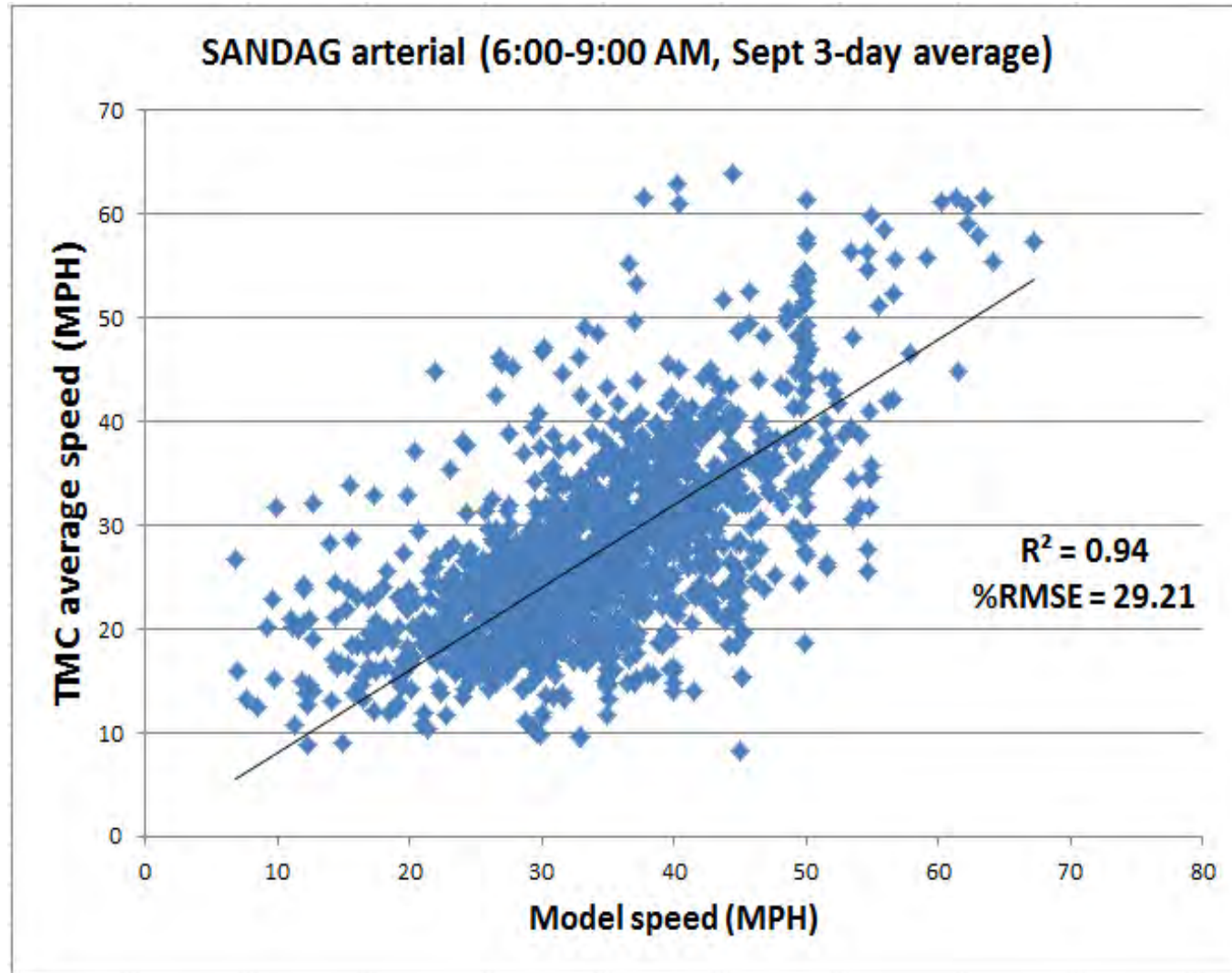| Highway assign RG	Type of model run	Δ PM VMT (Project–base)	Δ PM VHT (Project–base)	Δ PM Highway trips	Δ PM Transit trips	Δ PM PHT (Project-base)
1.E-4	Mode choice & assign only	-410	-60	-44	+66	+57
1.E-6	Mode choice & assign only	-660	-34	-41	+56	+40
1.E-4	model with feedback	-2,190	-107	-81	+65	+54
1.E-5	model with feedback	-654	-38	-36	+57	+33
1.E-6	model with feedback	-615	-32	-39	+59	+39

Auto Travel Time Analysis

- Comparison of model output congested travel times with HERE Real Time TMC data

- Comparisons for AM period and for various categories of facilities

- Comparison with INRIX and DTA speeds for MAG

- O-D travel time analysis using Google data

Highway Speed Comparison

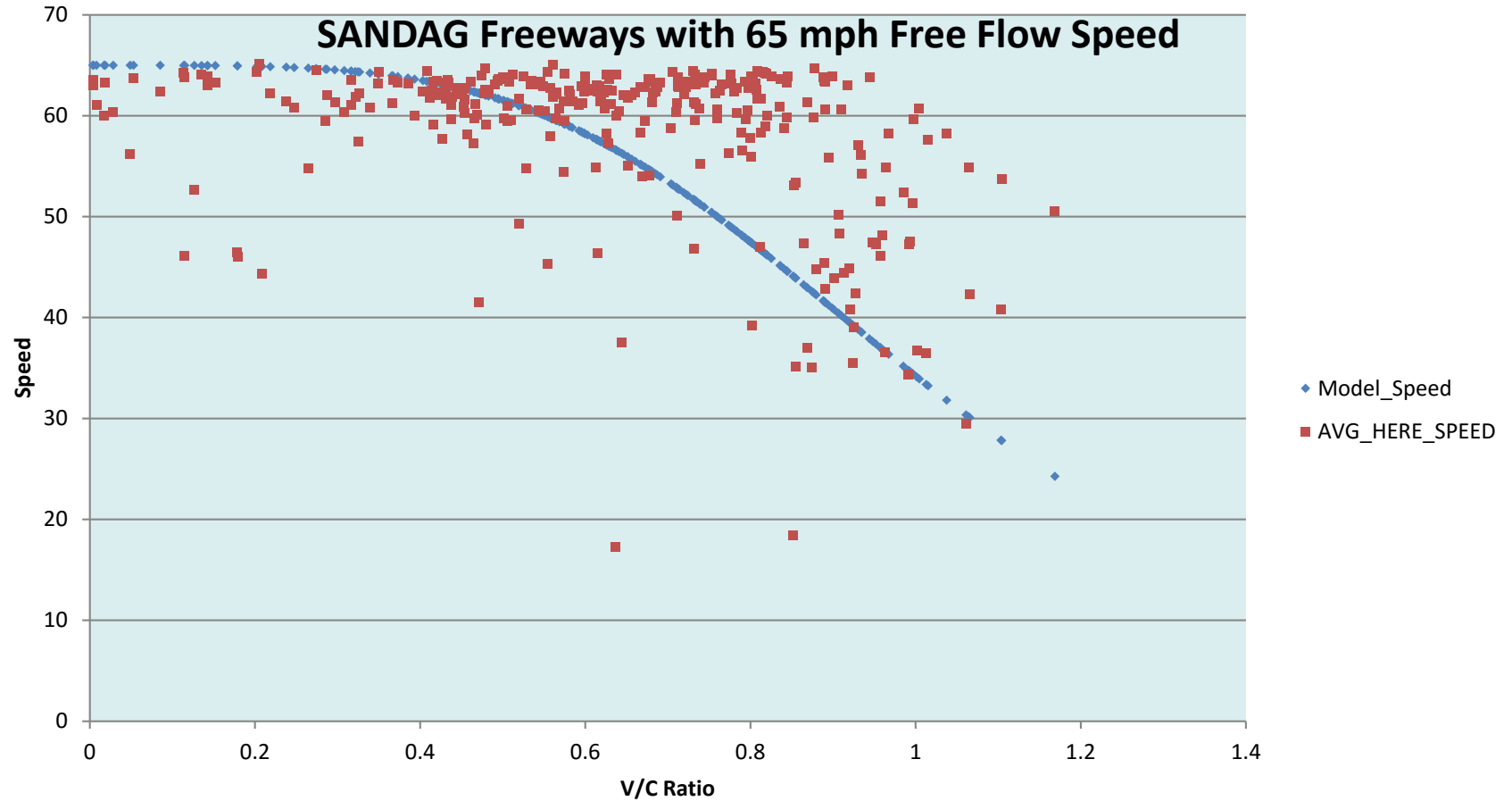SANDAG highway (6:00-9:00 AM, Sept 3-day average)

Arterial Speed Comparison

SANDAG arterial (6:00-9:00 AM, Sept 3-day average)

$R^2 = 0.94$
%RMSE = 29.21

Freeway speeds higher than predicted

SANDAG Freeways with 65 mph Free Flow Speed

Micro-simulated DTA v. Planning Model Travel Times

Comparison of travel times: Micro-simulation vs Planning model
Single trip OD pairs
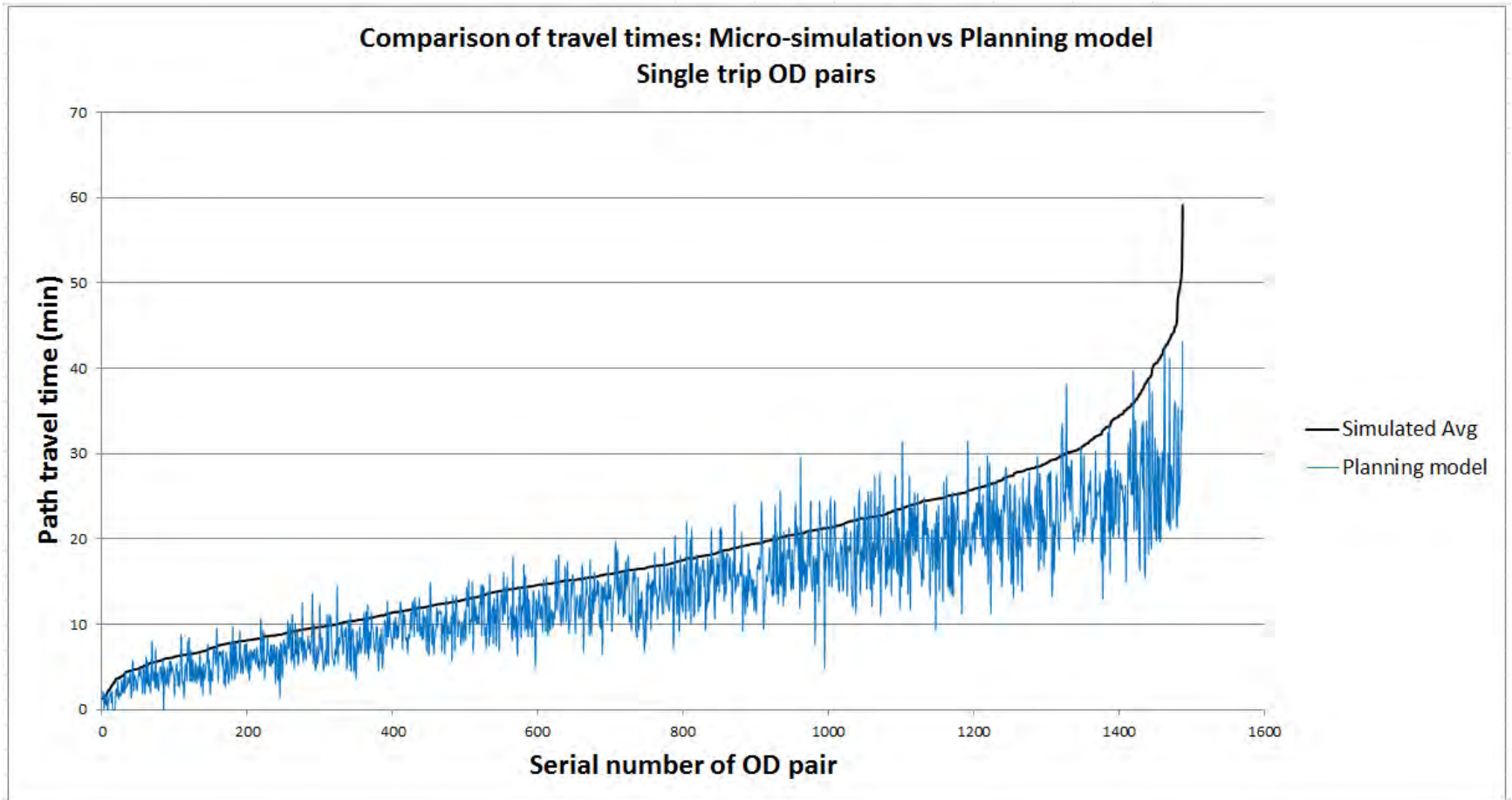
Micro-simulated DTA Times v. INRIX

Comparison of travel times: Micro-simulation model vs INRIX
Multi-trip OD pairs
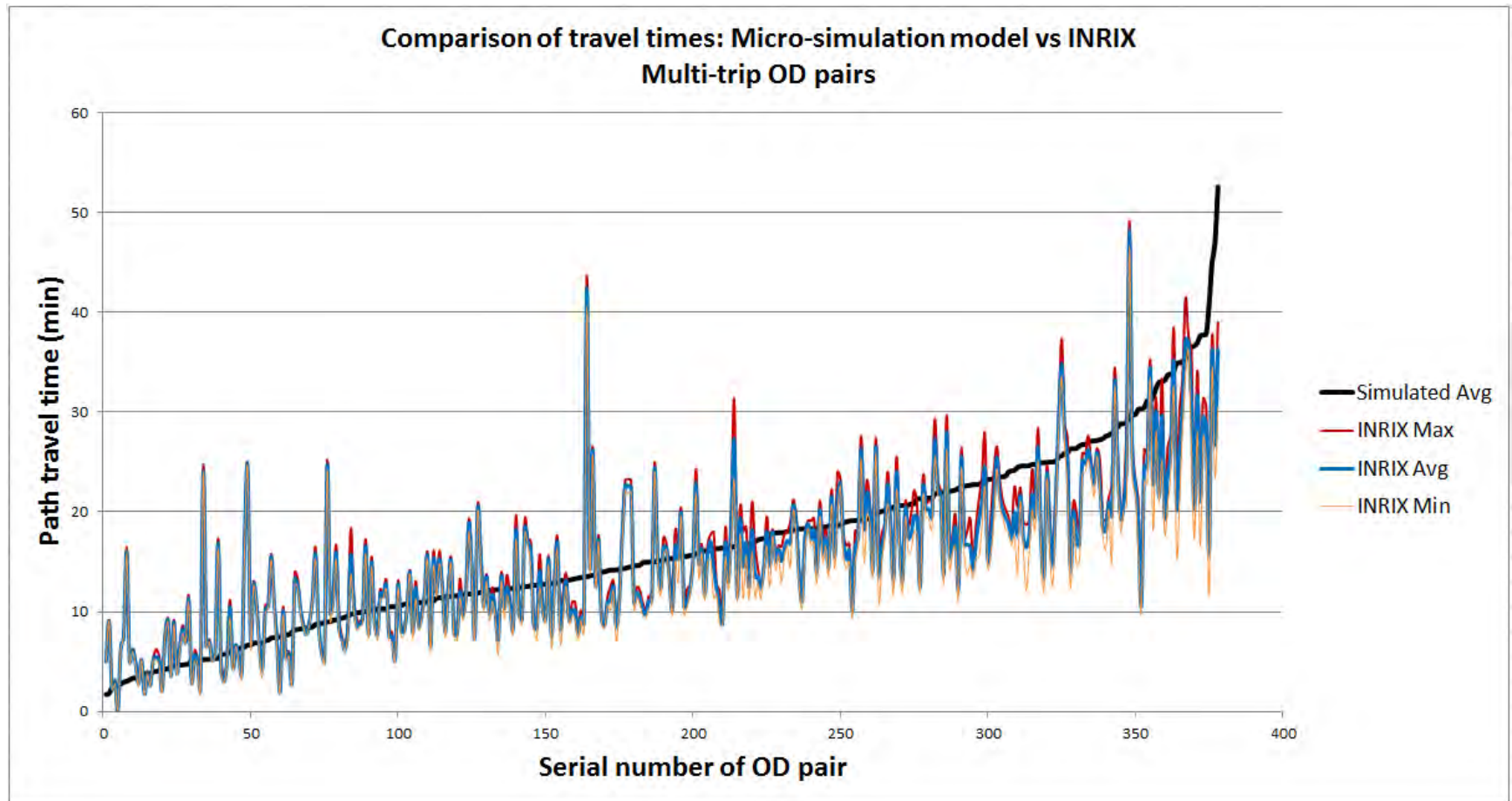
Comparison of Modeled and HERE travel times for the Atlanta Model

MCD-to-MCD travel times for ARC AM time period

District-to-district time (min) vs Number of district-to-district pairs

%RMSE = 11.87
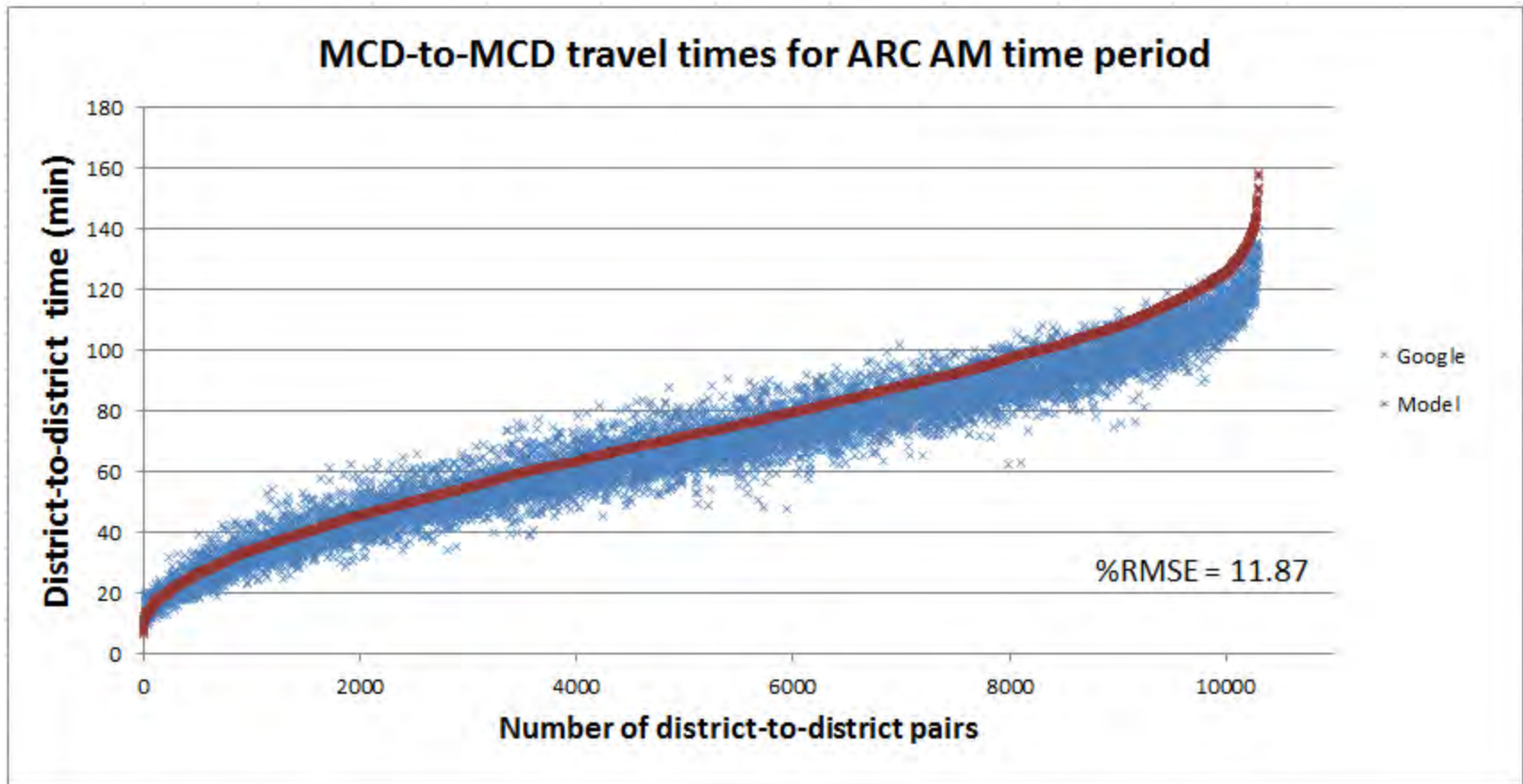
Google
Model

Comparison of Atlanta model and Google Travel Times to Downtown
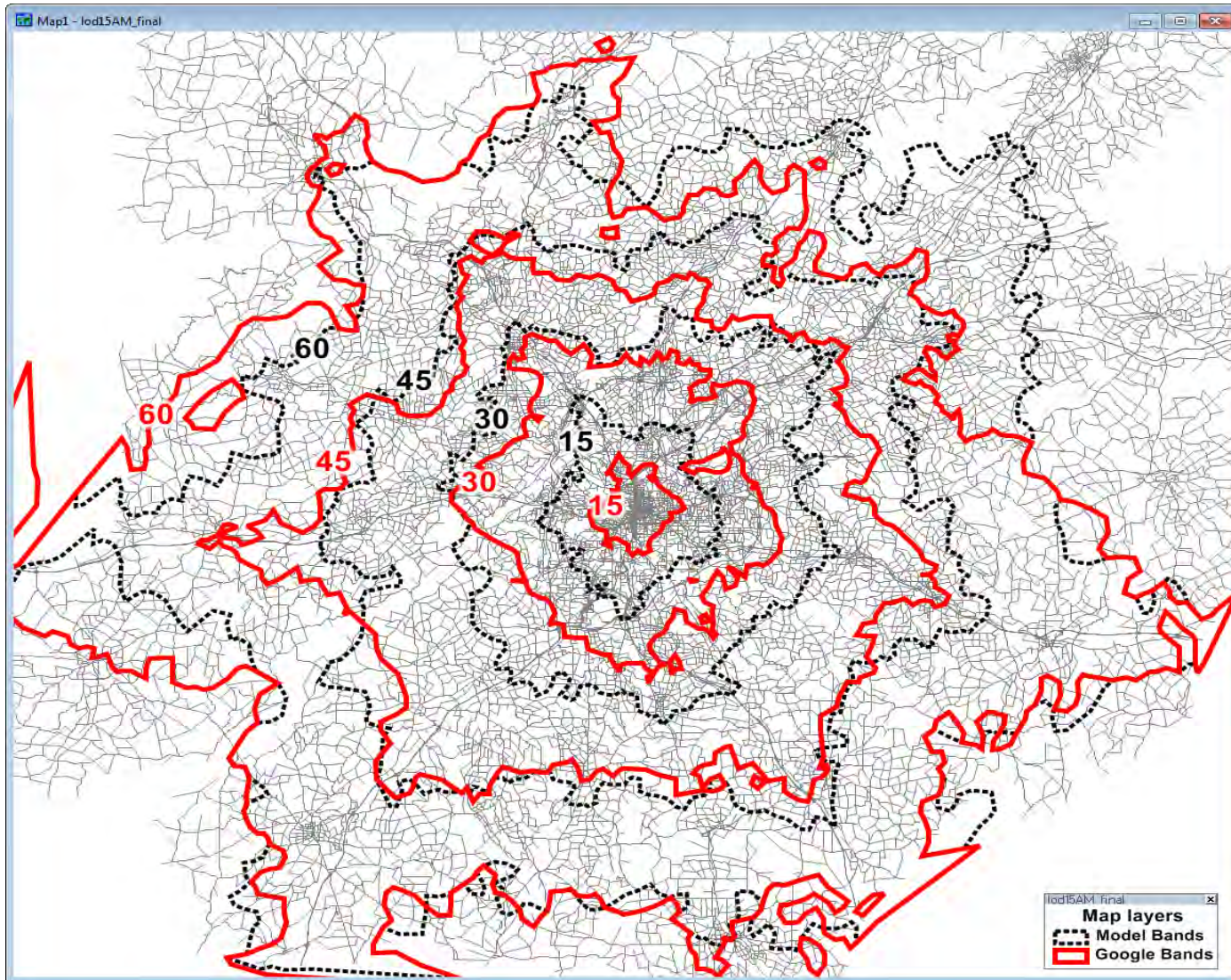
Congested Travel Time Comparisons

- Commercial sources make it easy to compare measured and modeled travel times

- MPO models do a poor job of matching measured congested travel times from commercial sources

- In general, model auto travel times are higher than the those that are measured

- Consequently, VHT tends to be overstated by models, perhaps transit utilization too

- Performance measurement based only on modeled speeds from MPO models may be unreliable

Some Overall Project Conclusions & Observations

- Estimates of project impacts vary significantly with traffic assignment convergence levels
- More convergence is needed but convergence is, by itself, not enough
- Better practices and better quality control are needed
- So are better modeled speeds and better validation
- Existing methods appear to be able to resolve project impacts including the highway impacts of transit projects when properly implemented
- Due to their potential unreliability, models should provide evidence of their efficacy

Some other considerations for MPOs

- Value of third party forensic review & testing
- Accuracy of trip tables
- Reliability of observed time-of-day count/speed data
- External validation through conduct of before-and-after studies

Project Final Report

The project final report can be downloaded from FTA

http://www.fta.dot.gov/documents/traffic-assignment-and-feedback-research-to-support-improved-travel-forecasting.pdf

Or the Caliper home page

http://www.caliper.com/PDFs/traffic-assignment-and-feedback-research-to-support-improved-travel-forecasting.pdf

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